UCRL-JRNL-213666

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July 18, 2005

Fusion Science And Technology

FABRICATION OF SURFACE BUMPS ON A CAPSULE TO SIMULATE FILL TUBE MASS DEFECTS

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Abstract

Precision single bumps were deposited on the surface of ICF capsules to simulate the hydrodynamic instability caused by a fill tube. The bump is fabricated by placing an aperture mask on the capsule and coating plasma polymer through the aperture. The apparatus and procedures used to align and hold the shell for coating will be described. Bumps were made having a width of about 50 µm and from 1 to 10 µm in height. The bumps were characterized using interference microscopy and AFM.

Introduction

Future ignition capsules on NIF may use fill tubes to allow filling with DT. (1, 2) Fluid dynamic simulations of the fill tube mass defect have shown that a jet instability will develop for sufficiently large defects. (2) Our goal was to fabricate single mass defects (bumps) on a capsule to simulate the defect caused by a fill tube. The bumps specified were to be roughly gaussian in shape, from 60 to 40 µm in diameter and from 1 to 10 µm high. The approach we used to fabricate the bump was to align a precision aperture to the capsule and coat through the aperture onto the capsule surface using plasma polymer coating technology (3). Previous work used a similar approach to fabricate micro-spot flat targets with various dopants for plasma temperature and stability measurements (4). The bumps were characterized using optical microscopy, white light interference microscopy (WYKO, Veeco), and AFM sphere mapping (5). Optical microscopy provided information on the uniformity of the bump. Interference microscopy provided a measure of the bump height. AFM was used to obtain precise profile measurements for a measure of bump volume.

Bump Fabrication

The bumps were prepared by coating through a precision aperture. The capsule was aligned to the aperture and held for coating using the fixture shown in figure 1. Apertures with a 50 µm diameter hole in a stainless steel foil 25 µm thick and 9.5 mm in diameter (Edmund Optical) were used as masks to define the area to be coated.

We found that it was important to inspect each aperture prior to coating because of the possibility of dirt particles in the aperture. Apertures were cleaned in ethanol using ultrasonic agitation dried and inspected. The clean apertures were installed in a mounting ring using acrylic cement (Duco) that allowed easy removal and reuse of the mounting ring. The mounting ring is the formed aluminum holder used to hold the aperture for shipping. The mounting ring allowed the surface of the aperture to be recessed below the outer edge by about 400 µm. This spacing allowed the tenting film to have a reasonable tightness over the 500 µm diameter shell. The mounted aperture was next placed into an aluminum fixture with a hole that accepted the aperture mount and also had tapped holes that received the bolts on the top holder. The shell was loaded onto the aperture surface. An attempt was made to locate the shell as close to the aperture hole as possible. A 2 µm thick polycarbonate film (Spectro-Film PolycarbTwo, Somar Int'l.) mounted in an x-ray fluorescence holder ring was anti-static treated with a polonium source and then carefully lowered over the capsule.

The capsule and aperture were viewed by microscope from above while lighting the aperture from below with a fiber optic illuminator. The ring-mounted film was then carefully translated to align the capsule to the aperture. All alignment was performed using only optical observation. This appeared sufficient to achieve an alignment accuracy of about 20 µm. The top holder was positioned carefully and the two bolts threaded loosely into the bottom mount. The alignment was retested and adjusted as needed and the clamping bolts were tightened. Since a stereo microscope was used for alignment it was necessary to compensate for parallax offset. The alignment was observed separately from each eyepiece to split the difference between the two views. The assembled structure was inverted and reexamined to assure accurate centering of the hole and the center of the capsule.

Figure 1 is a schematic drawing of the holding and alignment fixture for the shell and aperture showing the top and bottom holders, the XRF film holder ring with the polycarbonate film installed, and the shell and aperture in the mounting ring. Figure 2 is a photograph of the physical holding fixture.

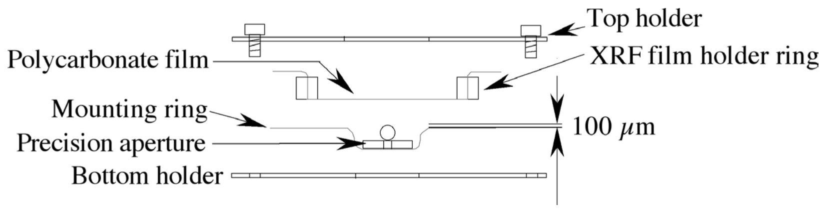

Fig. 1. Drawing of fixture to align and hold capsule and aperture in place for coating a bump on a capsule.

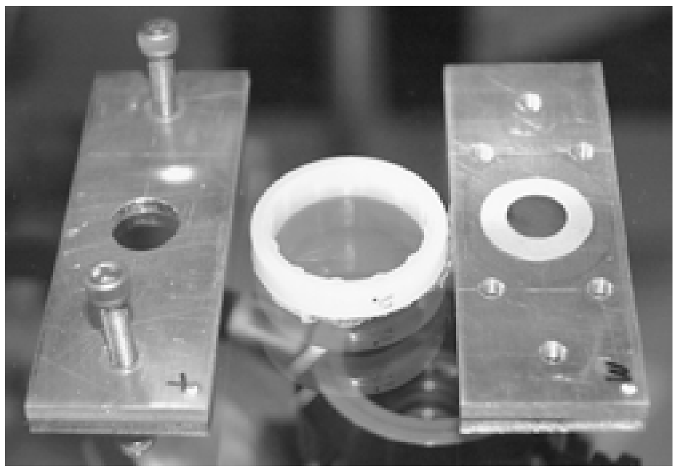

Fig. 2. Photograph of physical fixture diagrammed in figure 1.

Plasma Polymer Coating of Bumps

The fixture holding the capsule and aperture was placed in the plasma polymer coater with the aperture facing upward towards the plasma and the shell held below the aperture. The mounting fixture is thus inverted from the initial orientation used for alignment. The capsule holder was placed on the mounting table with a shim (0.160 inch thick) that provides a stable surface and provided clearance for the screw heads. The substrate holder was adjusted in height to 3.22 cm below the chamber edge. The capsule was aligned to within 1 mm of the center of the chamber using an acrylic alignment fixture. Witness surfaces were placed alongside the opening in the top holder plate to assist in getting deposition rate information. The gas flows were 0.3 sccm for trans-2-butene and 10 for hydrogen. The chamber pressure was controlled to 98 mTorr and the discharge power was 10 watts (3, 6). The rate of coating at this position deposited a 3 μm bump in 6.33 hours

Bump characterization

After coating the bump through the aperture the capsule was next mounted for characterization. To pick up the capsule a small piece of gel film (WF-80-X0, Gel-Pak, Inc.) about 3 mm square was adhered to a 1 x 3 inch glass slide. The slide was handled with thin forceps and carefully aligned over the capsule. The slide with the adhered gel film square was then slowly lowered, viewing through a microscope, until the capsule was just touching the gel film. The slide was carefully lifted off the aperture and inverted so that the capsule was facing upward. The capsule was next examined using a microscope to locate the bump feature. A vacuum chuck with a plastic tube was used to gently push and roll the capsule until the bump was precisely oriented upward at the “pole” position. An optical micrograph of a mounted capsule with a 55 x 3 μm bump is shown in Figure 3.

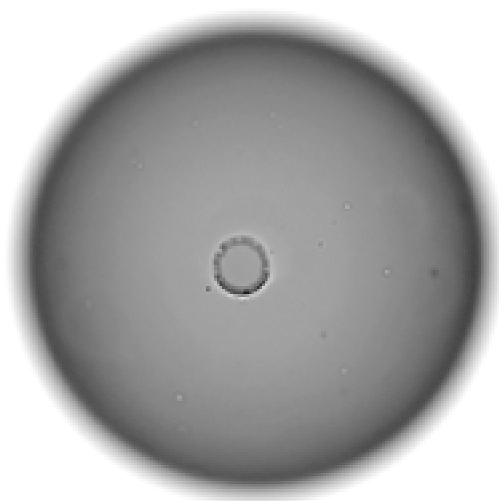

Fig. 3. Optical photomicrograph of capsule with CH bump on the pole.

The mounted shell was next examined on the inference microscope (WYKO). The capsule was first located at low magnification. The magnification was next increased to 50X and the stage tilted until the bump was precisely at the pole position and the interference fringes on the bump and on the shell are circular and concentric. A scan was taken and saved. The image was next masked to exclude the bump from the curvature correction, corrected for curvature and tilt, and the flattened image analyzed for feature dimensions. A WYKO image and profile measurement is shown in Figure 4. Because of the steepness of the edge of the bump the WYKO interferometer is unable to detect the fringe movement through this portion of the bump. The area that is not detected is shown as a black ring around the outer edge of the bump in the image.

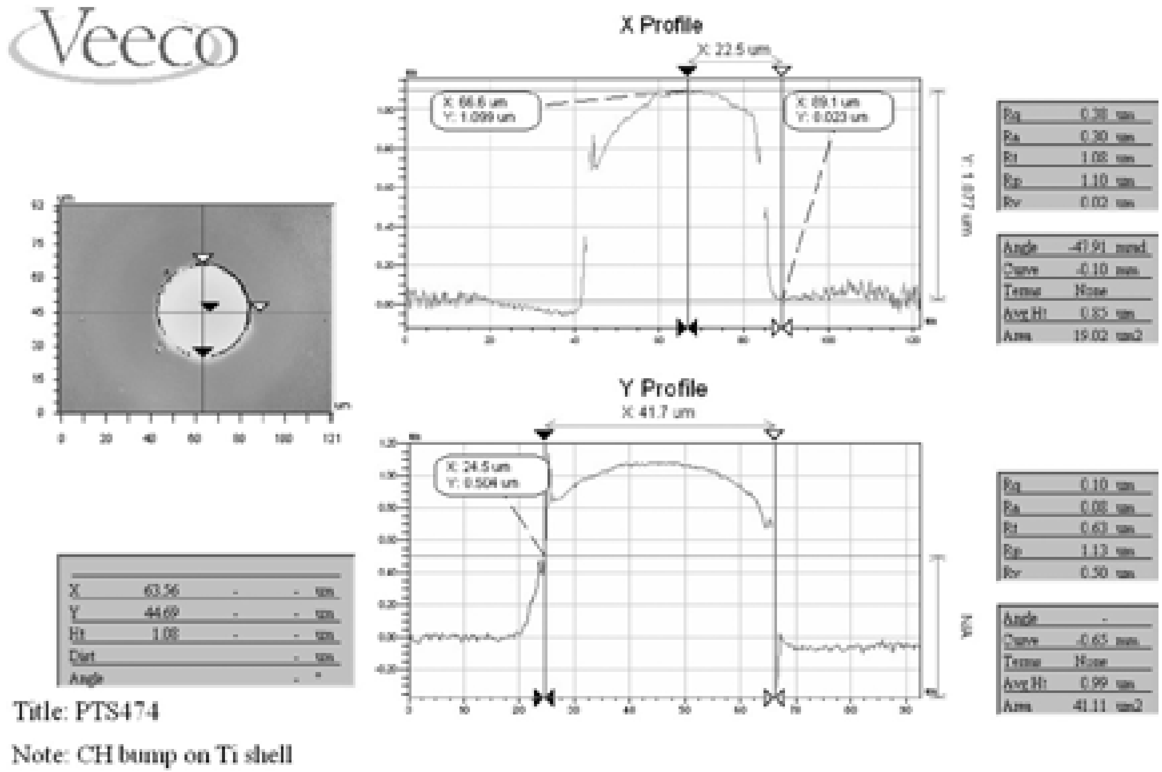

Fig. 4. Results from WYKO interference microscope for one of the bumps added to a capsule. Note the black area in the picture on the left, indicating no data.

The shell was next transferred to the sphere mapping AFM and held on a vertical vacuum chuck (5). The capsule was adjusted until the bump was positioned at the “equator” position, which frequently required several attempts to achieve a satisfactory alignment. The capsule was then rotated and traces were collected at spacing ranging from 5 to 10 µm intervals. AFM mapping is limited to bumps up to 5 µm high because of the 6 µm dynamic range limitation of the AFM probe. Figure 5 shows 10 AFM traces through a 60 x 3 µm bump. The bump shape qualitatively agrees with the profile found by interferometry but has the advantage of not being discontinuous because of the undetected steep edge region. The height measured on the WYKO and the AFM sphere mapper were consistently different with the WYKO measuring about 20% shorter heights. The discrepancy was caused by the calculated flattening correction on the WYKO. Bump width at half-height was calculated using the capsule diameter to convert degrees width to µm width.

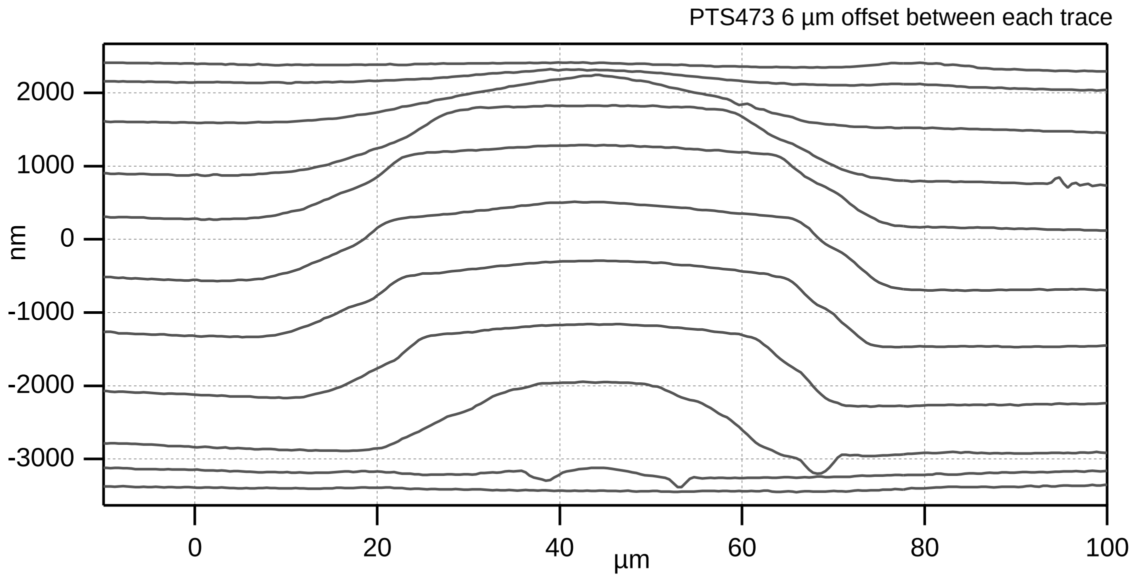

Fig. 6. AFM Sphere Mapper band map traces of a CH bump on a shell. The x-axis is µm around the equator where zero µm starts at an arbitrary position on the OD.

Summary

Bumps were fabricated by plasma polymer coating through a precision aperture. Bumps from less than 1 µm to more than 10 µm high were prepared. More than 50 capsules with bumps have been used in implosion experiments on the Omega laser at LLE.

Acknowledgement

This work was performed under the auspices of the U.S. Department of Energy by the University of California Lawrence Livermore National Laboratory under contract W-7405-Eng-48.

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